# Technical Report

# Balanced Capacitor Circuit for Ground Isolation

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## 1 Introduction

It is beleived that the coupling of the signal ground of the baseband system and the correlator signal ground can create subtle problems in the operation of the correlator. Therefore it has been proposed to use isolation transformers (IT) at the baseband to sampler interface. In this report we investige the feasibility of using two capacitors in the balance mode in place of the isolation transformer. This circuit is cost effective and have lower low-frequency cut off.

Fig. 1 shows the schematics of the two isolation schemes. GND1 and GND2 are the signal grounds in the baseband and correlator room respectively. A coaxial cable connects the baseband amplifier output to the sampler input. The isolation circuit is placed in this cable. The grounds GND1 & GND2 are connected at a common point as in any star grounding scheme. This means that the dc impedance between the grounds will be quite small. However the ac impedance can be considerably high and therefore a signal return path is essential, which is provided by the shield of the coaxial cable. Thus as far as the signals are concerned the isolation circuit can be considered as a balanced one. Also it should be noted that this circuit can only prevent a dc current (or low frequency) flowing between the two grounds through the signal return path due to any "ground potential difference". The two types of isolation schemes shown in Fig. 1 are functionally similar. The basic difference is that the signal is coupled magnetically in IT circuit and electrically in the capacitor circuit.

## 2 Specification

Since the isolation needed is at the base band the requirement of the isolation circuit is that it should have a flat response over $\sim$ 1.0 kHz to 16.0 MHz with an insertion loss of $<$ 1.0 dB. (The low frequency cut off is determined by the spectral line observation requirement.)

## 3 Comparison with Isolation transformer

Isolation transformers which satisfy the specification are commercially available. For comparing the two schemes of isolation we have chosen the Mini-Circuits IT TT1-6 and ceramic capacitors from Kemet (EIA[1] code for ceramic material X7R) & Gujarat Poly-AVX electronics Ltd (EIA code – Z5U). Table 1 lists the relavent characteristics of the two schemes. (See the copies of the data sheets attached here for other details.)

[1] Electronics Industry Association

Table 1: Characteristics of the two schemes of Isolation

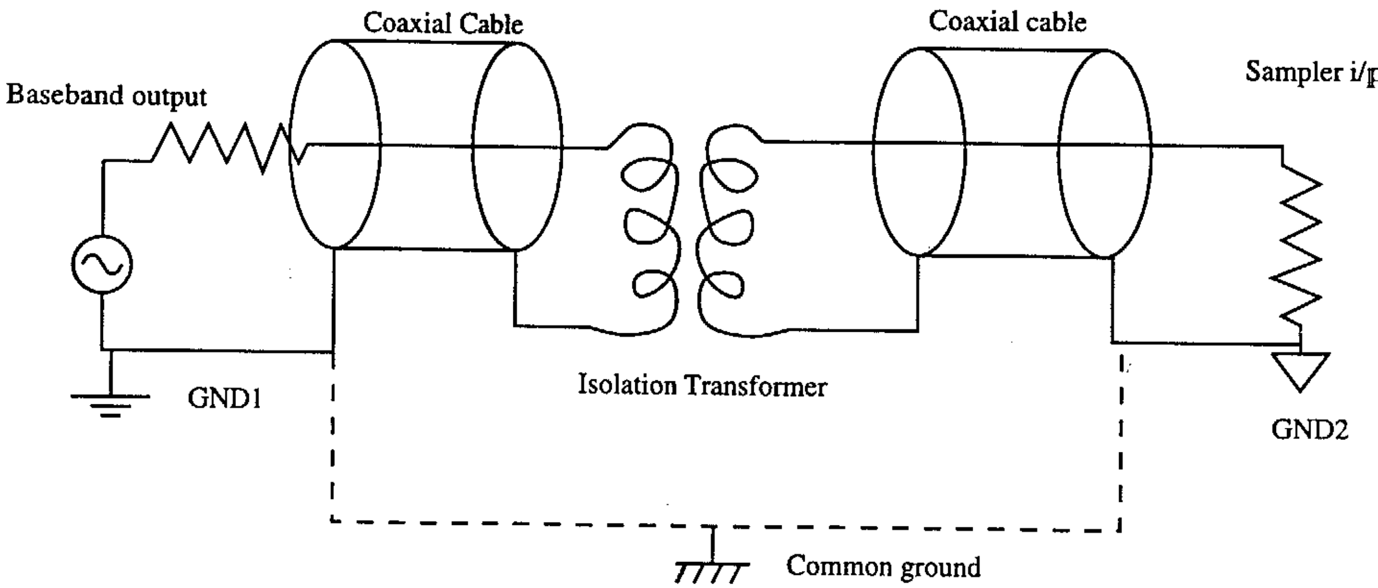
| | Isolation Transformer | Balanced Capacitor ckt |
|---|---|---|
| Freq. response (3 dB bw in MHz) | .004 – 500 | 0.0025 – > 500.0[a] |
| DC isolation ($\Omega$) | [b] | $10^{11}$(X7R), $10^{10}$(Z5U) |
| Break down voltage (V) | 1000 RMS | 100(X7R), 70(ZU5)[c] |
| Operating temperature ($^o$C) | -20 to +85 | -55 to +125 (X7R) |
| | | +10 to +85 (Z5U) |
| Cost (in $) | 4 – 7 | $\sim 2$[d] |

a) Measured with 50 $\Omega$ impedance (see Figs. 2b & 4)
b) Not specified in the Mini-Circuits data sheet.
c) 200% of the rated DC voltage.
d) Cost for two capacitors.

# 4 Frequency response

Fig. 2a & b shows the measured frequency response of the balanced capacitive coupling. We have used 1 $\mu$f ceramic capacitors of dielectric material X7R (Kemet) & ZU5 (Poly-AVX) for these measurements. The low frequency characteristics is measured using the HP Gain-Phase analyzer and the high frequency characteristics using the HP network analyzer. The measured phase response may have a linear residual because of the connector assembly in which the circuit is soldered. It should be noted that in these measurements the grounds will be internally connected in the measuring instrument. Therefore we have done measurements by connecting the circuit to the GMRT correlator. Fig. 3 shows the band shapes measured using the MkIII correlator with IT (home-made IT; built by Charudatta Kanda, Gopinathan and Praveen Kumar), balanced capacitor and without any isolation. For this experiment we connected a noise source at the input of the GMRT baseband system and its output is connected to the sampler through the isolation circuits. The low frequency 3 dB cutoff of the entire system (baseband + balanced capacitor isolation + sampler) with the balanced capacitor isolation is measured by reducing the baseband bandwidth to 62 kHz and the sampling frequency in the correlator to 250 kHz. The measured value is $\sim$ 2.5 kHz (see Fig. 4).

## Isolation Transformer Circuit




## Balanced Capacitor Circuit

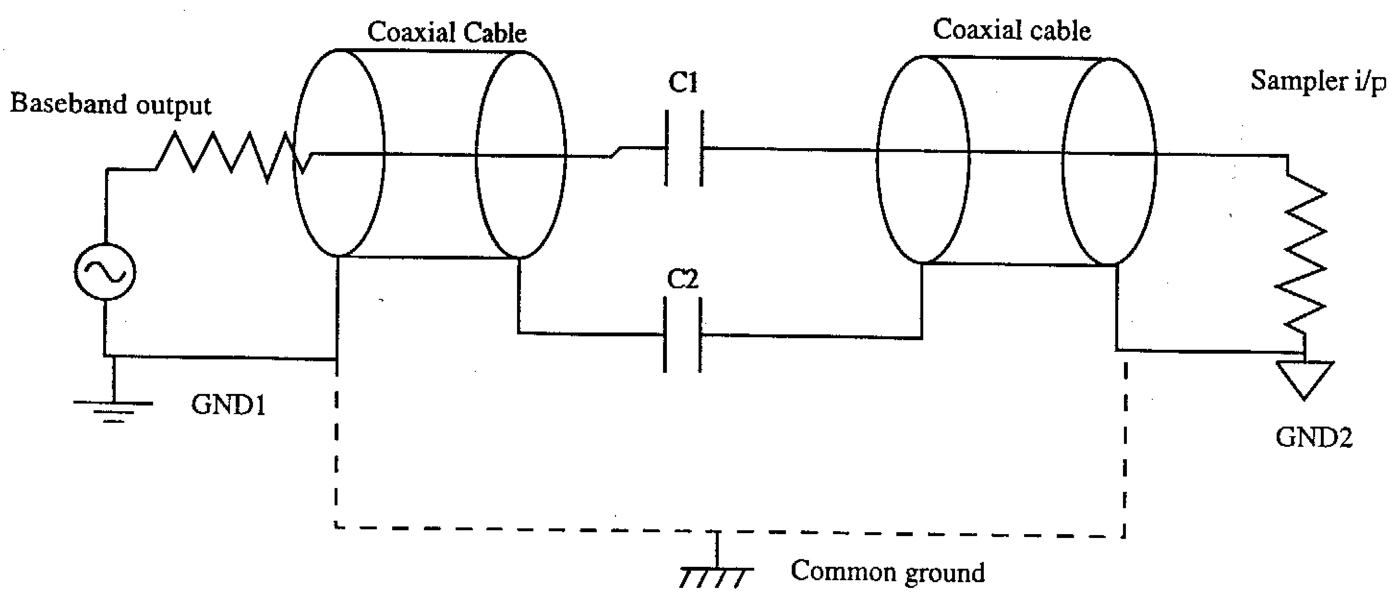



Figure 1

Response of Capacitor

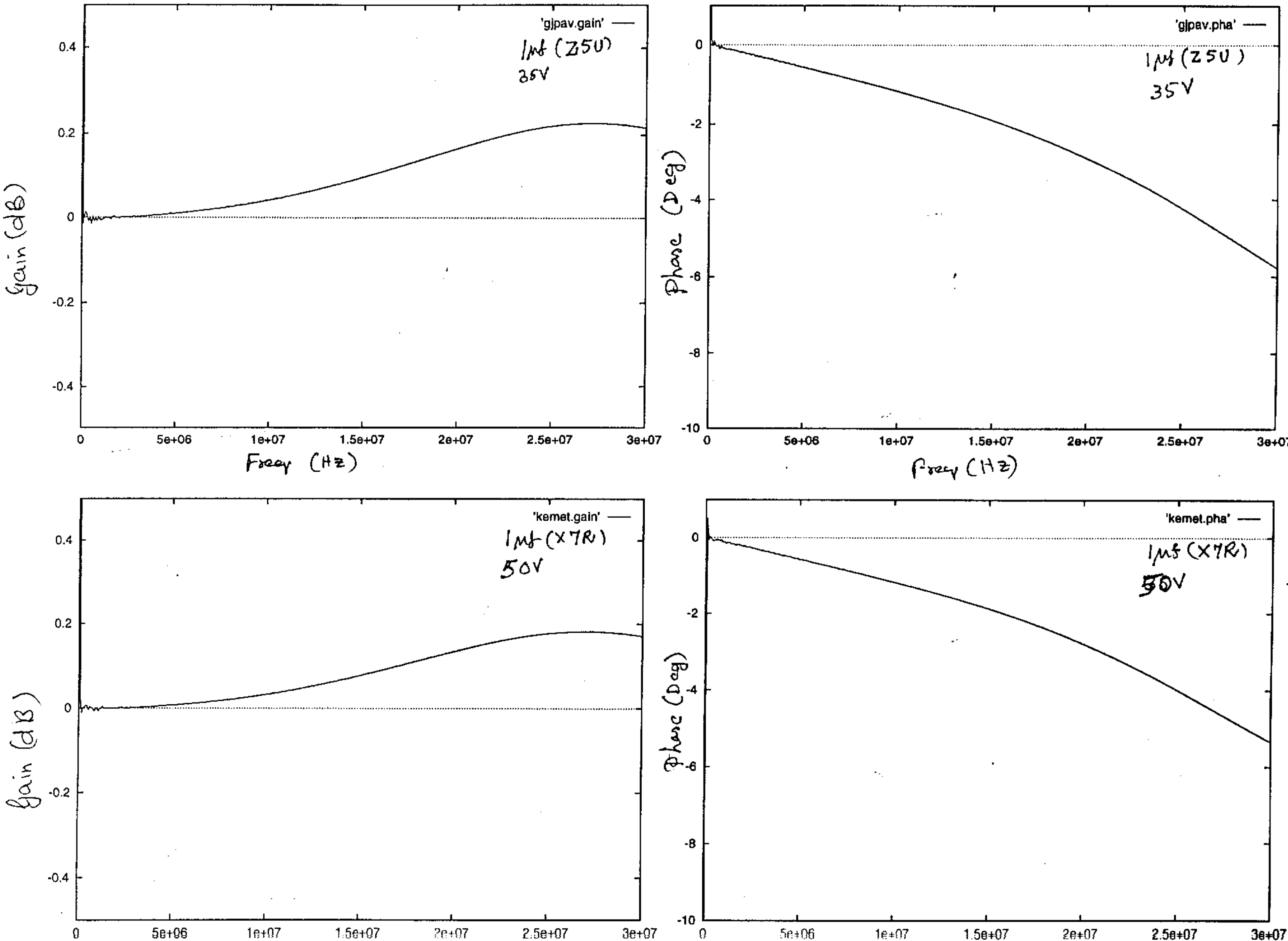



Fig 2a

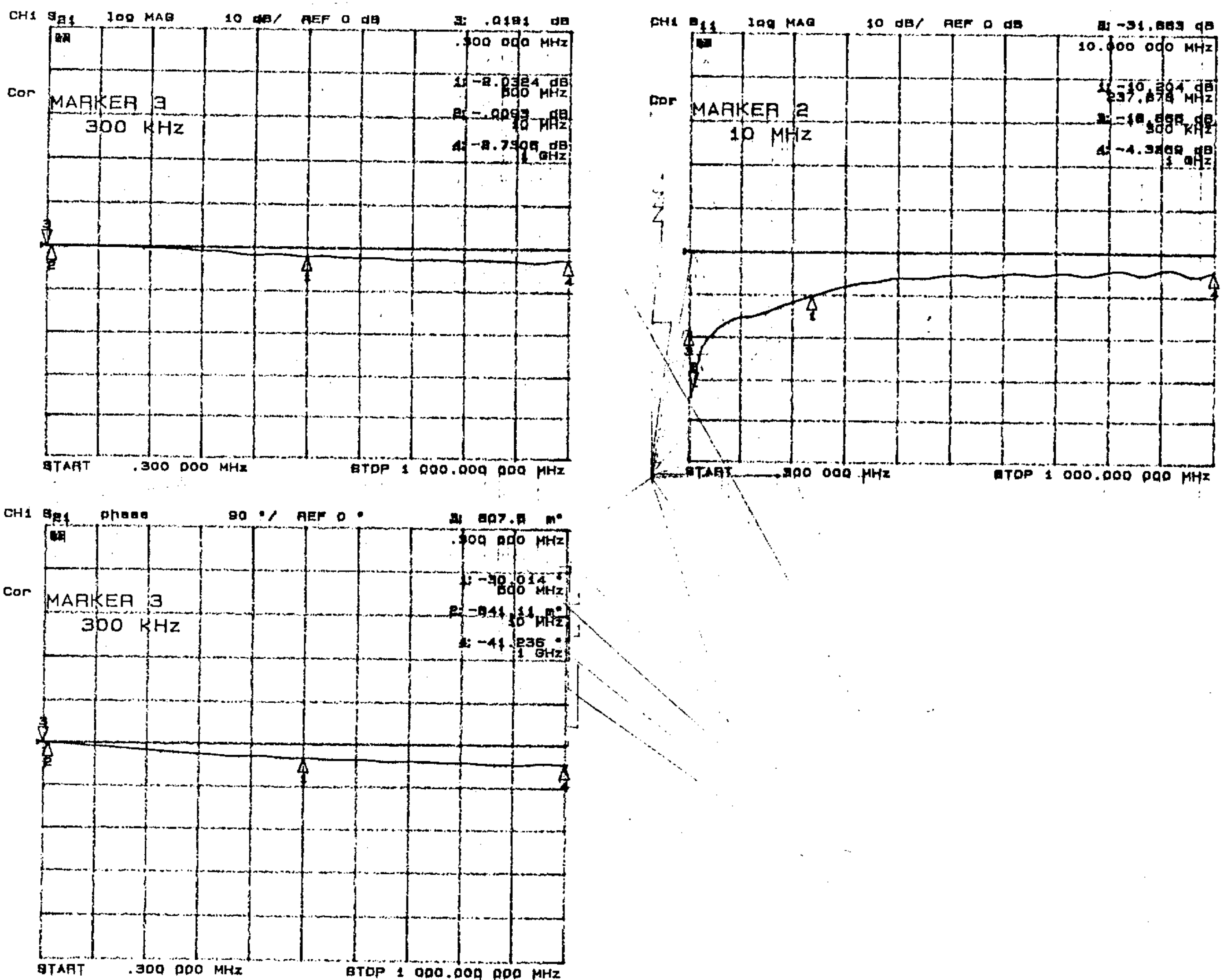

CH1 S21 log MAG 10 dB/ REF 0 dB
MARKER 3
300 KHz
START .300 000 MHz
STOP 1 000.000 000 MHz
CH1 S11 log MAG 10 dB/ REF 0 dB
MARKER 2
10 MHz
CH1 S21 phase 90 °/ REF 0 °
Cor

Fig 2b

Fig 2b

Band shapes measured by connecting the noise source at the IF input

# Band Pass measured using MK III Correlator

Fig 3

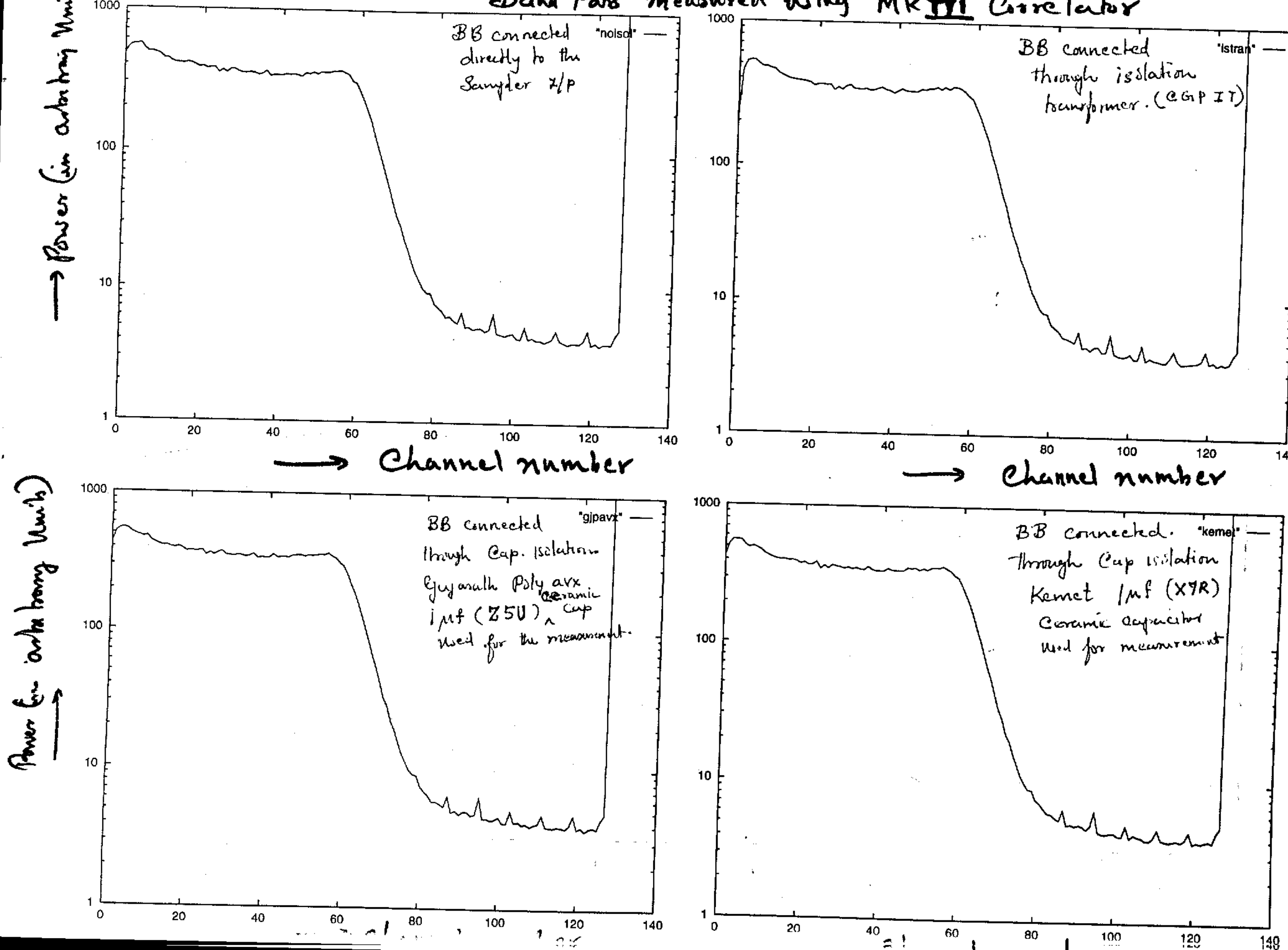



Fig 3

Base band bandwidth — ~62 kHz

Sampling freq — 256 kHz ⇒ Spectral resolution = 1 kHz

Spectrum obtained by averaging 5 show-acq data files.

Base band noise source used for the measurement

**Fig 4**

**Band Shape measured using MkIII Correlator**